

Claims

We claim:

- 1 1. A method for changing an electrical resistance of a resistor, comprising:
2 providing a resistor having a length L and a first electrical resistance R_1 ; and
3 exposing a portion of the resistor to a laser radiation for a time of exposure, wherein the
4 portion of the resistor includes a fraction F of the length L , wherein at an end of the time of
5 exposure the resistor has a second electrical resistance R_2 , and wherein R_2 is unequal to R_1 .
- 1 2. The method of claim 1, wherein a spot dimension of the laser radiation is less than a product
2 of F and L .
- 1 3. The method of claim 1, wherein $F = 1$, and wherein at the end of the exposing step the resistor
2 has partially reacted with the laser radiation.
- 1 4. The method of claim 1, wherein $F = 1$, and wherein at the end of the exposing step the resistor
2 has fully reacted with the laser radiation.
- 1 5. The method of claim 1, wherein $F < 1$, and wherein at the end of the exposing step the resistor
2 has partially reacted with the laser radiation.

1 6. The method of claim 1, wherein $F < 1$, and wherein at the end of the exposing step the resistor
2 has fully reacted with the laser radiation.

1 7. The method of claim 1, wherein $R_2 > R_1$.

1 8. The method of claim 1, wherein $R_2 < R_1$.

1 9. The method of claim 1, wherein a product of F and L does not exceed about 1 micron.

1 10. The method of claim 1, wherein the resistor in the providing step includes a layer of a first
2 electrically conductive material in electrically conductive contact with a layer of a second
3 electrically conductive material, wherein the exposing step causes a portion of the first
4 electrically conductive material to react with a portion of the second electrically conductive
5 material to form a cell of a third electrically conductive material within the portion of the
6 resistor.

1 11. The method of claim 10, wherein $R_2 > R_1$.

1 12. The method of claim 11, wherein the first electrically conductive material includes titanium,
2 wherein the second electrically conductive material includes aluminum, and wherein the third
3 electrically conductive material includes titanium trialuminide.

1 13. The method of claim 10, wherein $R_2 < R_1$.

1 14. The method of claim 13, wherein the first electrically conductive material includes cobalt,
2 wherein the second electrically conductive material includes silicon, and wherein the third
3 electrically conductive material includes cobalt silicide.

1 15. The method of claim 1, wherein the resistor in the providing step includes an amorphous
2 metallic material, wherein the exposing step transforms a portion of the amorphous metallic
3 material into a crystalline metallic material within the portion of the resistor.

1 16. The method of claim 15, wherein the amorphous metallic material is selected from the group
2 consisting of titanium nitride, tantalum silicon nitride, and tungsten nitride.

1 17. The method of claim 1, wherein the resistor in the providing step includes a polycrystalline
2 metal, wherein the exposing step transforms a first crystalline phase of the polycrystalline metal
3 into a second crystalline phase of the polycrystalline metal within the portion of the resistor.

1 18. The method of claim 17, wherein the polycrystalline metal includes tantalum, wherein the
2 first crystalline phase includes a tetragonal phase, and wherein the second crystalline phase
3 includes a body-centered cubic phase.

1 19. The method of claim 1, wherein the resistor in the providing step includes a metallic oxide
2 selected from the group consisting of a metal oxide and a metallic alloy oxide, wherein the
3 exposing step reacts a portion of the metallic oxide to form a metallic component and oxygen gas
4 within the portion of the resistor, wherein the metallic component is the metal if the metallic
5 oxide is the metal oxide, and wherein the metallic component is the metallic alloy if the metallic
6 oxide is the metallic alloy oxide.

1 20. The method of claim 19, wherein the metal oxide is platinum oxide, palladium oxide,
2 irridium oxide, or platinum palladium oxide.

1 21. The method of claim 1, wherein the resistor in the providing step includes N layers denoted
2 as layers 1, 2, ..., N, wherein N is at least 2, wherein layer I includes an electrically conductive
3 material M_I for $I = 1, 2, \dots, N$, wherein layer J is in electrically conductive contact with layer J+1
4 for $J = 1, 2, \dots, N-1$, wherein the exposing step causes a portion of the electrically conductive
5 material M_K to react with a portion of the electrically conductive material M_{K+1} to form an
6 electrically conductive cell $C_{K,K+1}$ within the portion of the resistor, and wherein K is selected
7 from the group consisting of 1, 2, ..., N-1, and combinations thereof.

1 22. The method of claim 1, further comprising exposing the portion of the resistor to the laser
2 radiation for an additional period of time, resulting in the resistor having a third electrical
3 resistance that differs from the second electrical resistance.

1 23. The method of claim 1, further comprising exposing the portion of the resistor to the laser
2 radiation for an additional period of time, resulting in the resistor having a third electrical
3 resistance that is about equal to the second electrical resistance.

1 24. The method of claim 1, wherein the resistor is coupled to a semiconductor substrate.

1 25. The method of claim 24, wherein the substrate includes an insulator and a plate, wherein the
2 insulator is disposed between the resistor and the plate, and wherein the plate is capable of
3 absorbing the laser radiation.

1 26. The method of claim 24, wherein the plate includes a metal.

1 27. The method of claim 25, further comprising exposing the plate to a portion of the laser
2 radiation, wherein the portion of the laser radiation does not pass through a total thickness of the
3 plate.

1 28. The method of claim 24, further comprising:
2 providing a predetermined target resistance in terms of a value R_t and a tolerance ΔR_t for
3 the second electrical resistance; and
4 testing the resistor after the exposing step to determine whether the second electrical
5 resistance is within $R_t \pm \Delta R_t$.

1 29. The method of claim 28, wherein after the testing step the second electrical resistance is not
2 within $R_t \pm \Delta R_t$, and further comprising if $(R_2 - R_1) (R_1 - R_2) > 0$ iterating such that each iteration of
3 the iterating includes:

4 additionally exposing the portion of the resistor to the laser radiation resulting in a new
5 second electrical resistance R_2' ;

6 additionally testing the resistor after the additionally exposing step to determine whether
7 R_2' is within $R_t \pm \Delta R_t$, and ending the iterating if R_2' is within $R_t \pm \Delta R_t$ or if $(R_2' - R_1) (R_1 - R_2') <$
8 0.

1 30. The method of claim 24, further comprising:

2 providing a predetermined target resistance in terms of a value R_t and a tolerance ΔR_t for
3 the second electrical resistance; and

4 testing the resistor during the exposing step to determine whether the second electrical
5 resistance is within $R_t \pm \Delta$.

1 31. The method of claim 30, wherein during the testing step the second electrical resistance is not
2 within $R_t \pm \Delta R_t$, and further comprising if $(R_2 - R_1) (R_1 - R_2) > 0$ iterating such that each iteration of
3 the iterating includes additionally testing the resistor during the exposing step to determine
4 whether R_2'' is within $R_t \pm \Delta R_t$, and ending the iterating if R_2'' is within $R_t \pm \Delta R_t$ or if $(R_2'' - R_1)$
5 $(R_1 - R_2'') < 0$, wherein R_2'' is a latest value of the second electrical resistance as determined by the
6 testing.

1 32. The method of claim 31, wherein the laser radiation is selected from the group consisting of a
2 continuous laser radiation and a pulsed laser radiation.

1 33. The method of claim 24, further comprising:
2 conductively coupling a first electrically conductive contact to the resistor;
3 conductively coupling a second electrically conductive contact to the resistor; and
4 conductively coupling an electrical circuit element to the first electrically conductive
5 contact and to the second electrically conductive, wherein an electrical circuit is formed such that
6 the electrical circuit includes the electrical circuit element and the resistor.

1 34. An electrical structure, comprising:
2 a resistor having a length L and an electrical resistance $R(t)$ at a time t ; and
3 a laser radiation directed onto a portion of the resistor, wherein the portion of the resistor
4 includes a fraction F of the length L , and wherein the laser radiation heats the portion of the
5 resistor such that the electrical resistance $R(t)$ instantaneously changes at a rate dR/dt .

1 35. The electrical structure of claim 34, wherein a spot dimension of the laser radiation is less
2 than the length L .

1 36. The electrical structure of claim 34, wherein $F = 1$.

1 37. The electrical structure of claim 34, wherein $F < 1$.

1 38. The electrical structure of claim 34, wherein $dR/dt > 0$.

1 39. The electrical structure of claim 34, wherein $dR/dt < 0$.

1 40. The electrical structure of claim 34, wherein $dR/dt = 0$.

1 41. The electrical structure of claim 34, wherein a product of F and L does not exceed about 1
2 micron.

1 42. The electrical structure of claim 34, wherein the resistor includes a layer of a first electrically
2 conductive material coupled to a layer of a second electrically conductive material by a cell of a
3 third electrically conductive material that is within the portion of the resistor, and wherein the
4 third electrically conductive material includes a chemical combination of the first electrically
5 conductive material and the second electrically conductive material.

1 43. The electrical structure of claim 42, wherein $dR/dt > 0$.

1 44. The electrical structure of claim 43, wherein the first electrically conductive material includes
2 titanium, wherein the second electrically conductive material includes aluminum, and wherein
3 the third electrically conductive material includes titanium trialuminide.

1 45. The electrical structure of claim 42, wherein $dR/dt < 0$.

1 46. The electrical structure of claim 45, wherein the first electrically conductive material includes
2 cobalt, wherein the second electrically conductive material includes silicon, and wherein the third
3 electrically conductive material includes cobalt silicide.

1 47. The electrical structure of claim 34, wherein the resistor comprises an amorphous metallic
2 material, wherein a cell of the amorphous metallic material within the portion of the resistor is
3 coupled to a cell of a crystalline metallic material within the portion of the resistor, and wherein
4 the crystalline metallic material has resulted from an interaction of the laser radiation with the

5 amorphous metallic material.

1 48. The electrical structure of claim 47, wherein the amorphous metallic material is selected from
2 the group consisting of titanium nitride, tantalum silicon nitride, and tungsten nitride.

1 49. The electrical structure of claim 34, wherein the resistor comprises a polycrystalline metal
2 having a first crystalline phase, wherein a cell of the polycrystalline metal within the portion of
3 the resistor is coupled to a cell of a second crystalline phase of the polycrystalline metal within
4 the portion of the resistor, and wherein the second phase of the polycrystalline metal has resulted
5 from an interaction of the laser radiation with the first phase of the polycrystalline metal.

1 50. The electrical structure of claim 49, wherein the polycrystalline metal includes tantalum,
2 wherein the first crystalline phase includes a tetragonal phase, and wherein the second crystalline
3 phase includes a body-centered cubic phase.

1 51. The electrical structure of claim 34, wherein the resistor comprises a metallic oxide selected
2 from the group consisting of a metal oxide and a metallic alloy oxide, wherein a cell of the
3 metallic oxide within the portion of the resistor is coupled to a cell of a metallic component
4 within the portion of the resistor, wherein the metallic component is the metal if the metallic
5 oxide is the metal oxide, wherein the metallic component is the metallic alloy if the metallic
6 oxide is the metallic alloy oxide, and wherein the metallic component has resulted from an
7 interaction of the laser radiation with the metallic oxide.

1 52. The electrical structure of claim 51, wherein the metallic oxide is platinum oxide, palladium
2 oxide, irridium oxide, or platinum palladium oxide.

1 53. The electrical structure of claim 34,
2 wherein the resistor comprises N layers denoted as layers 1, 2, ..., N;
3 wherein N is at least 2;
4 wherein layer I includes an electrically conductive material M_I for $I=1, 2, \dots, N$;
5 wherein layer J is in electrically conductive contact with layer J+1 for $J = 1, 2, \dots, N-1$;
6 and
7 wherein a cell $C_{K,K+1}$ couples a cell C_K' of the layer K to a cell C_{K+1}' of the layer K+1,
8 wherein the cell C_K' is within the portion of the resistor and includes the material M_K , wherein
9 the cell C_{K+1}' is within the portion of the resistor and includes the material M_{K+1} , wherein the cell
10 $C_{K,K+1}$ is within the portion of the resistor and includes an electrically conductive material $M_{K,K+1}$
11 that comprises a chemical combination of the material M_K from the layer K and the material M_{K+1}
12 from the layer K+1, and wherein K is selected from the group consisting of 1, 2, ..., N-1, and
13 combinations thereof.

1 54. The electrical structure of claim 34, wherein the resistor is coupled to a semiconductor
2 substrate.

1 55. An electrical resistor of length L , comprising N layers denoted as layers 1, 2, ..., N :
2 wherein a portion of the resistor includes a fraction F of the length L ;
3 wherein N is at least 2;
4 wherein layer I includes an electrically conductive material M_I for $I=1, 2, \dots, N$;
5 wherein layer J is in electrically conductive contact with layer $J+1$ for $J = 1, 2, \dots, N-1$;
6 and
7 wherein a cell $C_{K,K+1}$ couples a cell C_K' of the layer K to a cell C_{K+1}' of the layer $K+1$,
8 wherein the cell C_K' is within the portion of the resistor and includes the material M_K , wherein
9 the cell C_{K+1}' is within the portion of the resistor and includes the material M_{K+1} , wherein the cell
10 $C_{K,K+1}$ is within the portion of the resistor and includes an electrically conductive material $M_{K,K+1}$
11 that comprises a chemical combination of the material M_K from the layer K and the material M_{K+1}
12 from the layer $K+1$, and wherein K is selected from the group consisting of 1, 2, ..., $N-1$, and
13 combinations thereof.

1 56. The electrical resistor of claim 55, wherein $F = 1$.

1 57. The electrical resistor of claim 55, wherein $F < 1$.

1 58. The electrical resistor of claim 55, wherein a product of F and L does not exceed about 1
2 micron.

1 59. The electrical resistor of claim 55, wherein $N=2$.

1 60. The electrical resistor of claim 59, wherein the electrically conductive material M_1 includes
2 titanium, wherein the electrically conductive material M_2 includes aluminum, and wherein the
3 electrically conductive material $M_{1,2}$ includes titanium trialuminide.

1 61. The electrical resistor of claim 59, wherein the electrically conductive material M_1 includes
2 cobalt, wherein the electrically conductive material M_2 includes aluminum, and wherein the
3 electrically conductive material $M_{1,2}$ includes cobalt silicide.

1 62. The electrical resistor of claim 55, further comprising:
2 a semiconductor substrate coupled to the resistor;
3 a first electrically conductive contact conductively coupled to the resistor;
4 a second electrically conductive contact conductively coupled to the resistor; and
5 an electrical circuit element coupled to the first electrically conductive contact and to the
6 second electrically conductive, wherein an electrical circuit includes the electrical circuit element
7 and the resistor.

1 63. An electrical resistor of length L , comprising:
2 a first portion having a length L_1 , wherein the first portion includes at least one cell
3 having an electrically conductive material with a first structure; and
4 a second portion of length L_2 such that $L_2 = L - L_1$, wherein the second portion includes a
5 fraction F of the length L such that $F = L_2/L$, wherein the second portion includes a structured
6 cell having the electrically conductive material with a second structure, and wherein the
7 electrically conductive material with the second structure has resulted from a laser heating of the
8 electrically conductive material with the first structure.

1 64. The electrical resistor of claim 63, wherein the first structure includes an amorphous metallic
2 material structure, and wherein the second structure includes a crystalline metallic structure.

1 65. The electrical resistor of claim 64, wherein the amorphous metallic material structure
2 includes an amorphous metallic material selected from the group consisting of titanium nitride,
3 tantalum silicon nitride, and tungsten nitride.

1 66. The electrical resistor of claim 63, wherein the electrically conducting material includes a
2 polycrystalline metal, wherein the first structure includes a first crystalline phase, and wherein
3 the second structure includes a second crystalline phase.

1 67. The electrical resistor of claim 66, wherein the polycrystalline metal includes tantalum,
2 wherein the first crystalline phase includes a tetragonal phase, and wherein the second crystalline

3 phase includes a body-centered cubic phase.

1 68. The electrical resistor of claim 63, wherein the first structure includes a metallic oxide
2 selected from the group consisting of a metal oxide and a metallic alloy oxide, and wherein the
3 second structure includes a metallic component, wherein the metallic component is the metal if
4 the metallic oxide is the metal oxide, and wherein the metallic component is the metallic alloy if
5 the metallic oxide is the metallic alloy oxide.

1 69. The electrical resistor of claim 68, wherein the metal oxide is platinum oxide, palladium
2 oxide, irridium oxide, or platinum palladium oxide.

1 70. The electrical resistor of claim 63, wherein the second portion further comprises a first
2 structured cell that includes the electrically conductive material with the first structure, and
3 wherein the first structured cell is coupled to the structured cell.

1 71. The electrical resistor of claim 63, wherein the at least one cell includes a first cell and a
2 second cell, and wherein the structured cell is disposed between the first cell and the second cell.

1 72. The electrical resistor of claim 63, wherein $F = 1$.

1 73. The electrical resistor of claim 63, wherein $F < 1$.

1 74. The electrical resistor of claim 63, wherein a product of F and L does not exceed about 1
2 micron.

1 75. The electrical resistor of claim 63, further comprising:
2 a semiconductor substrate coupled to the resistor;
3 a first electrically conductive contact conductively coupled to the resistor;
4 a second electrically conductive contact conductively coupled to the resistor; and
5 an electrical circuit element coupled to the first electrically conductive contact and to the
6 second electrically conductive, wherein an electrical circuit includes the electrical circuit element
7 and the resistor.